NEWTON'S APPLE®

Multimedia

Antibiotics

Cancer

Teacher's Guide

NEWTON'S APPLE Multimedia

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Introduction

Welcome to the *Newton's Apple* Multimedia Collection™!

Drawing from material shown on public television's Emmy-award-winning science series, the multimedia collection covers a wide variety of topics in earth and space science, physical science, life science, and health. The *Newton's Apple Multimedia Collection* contains a CD-ROM, a printed Teacher's Guide, a video with two Newton's Apple® segments and a scientist profile, and a tutorial video.

The Teacher's Guide provides three inquiry-based activities for each of the topics, background information, assessments, and a bibliography of additional resources.

The CD-ROM holds a wealth of information that you and your students can use to enhance science learning. Here's what you'll find on the CD-ROM:

- two full video segments from *Newton's Apple*
- additional visual resources for each of the *Newton's Apple* topics
- background information on each topic
- a video profile of a living scientist working in a field related to the *Newton's Apple* segments
- an Adobe Acrobat® file containing the entire teacher's manual along with student reproducibles
- UGather® and UPresent® software that allows you and your students to create multimedia presentations
- QuickTime® 3.0, QuickTime® 3 Pro, and Adobe Acrobat® Reader 3.0 installers in case you need to update your current software

The *Newton's Apple Multimedia Collection* is designed to be used by a teacher guiding a class of students. Because the videos on the CD-ROM are intended to be integrated with your instruction, you may find it helpful to connect your computer to a projection system or a monitor that is large enough to be viewed by the entire class. We have included a videotape of the segments so that you can use a VCR if it is more convenient. Although the CD-ROM was designed for teachers, it can also be used by individuals or cooperative groups.

With the help of many classroom science teachers, the staff at *Newton's Apple* has developed a set of lessons, activities, and assessments for each video segment. The content and pedagogy conform with the National Science Education Standards and most state and local curriculum frameworks. This Teacher's Guide presents lessons using an inquiry-based approach.

If you are an experienced teacher, you will find material that will help you expand your instructional program. If you are new to inquiry-based instruction, you will find information that will help you develop successful instructional strategies, consistent with the National Science Education Standards. Whether you are new to inquiry-based instruction or have been using inquiry for years, this guide will help your students succeed in science.

WE SUPPORT THE NATIONAL SCIENCE EDUCATION STANDARDS

The *National Science Education Standards* published by the National Research Council in 1996 help us look at science education in a new light. Students are no longer merely passive receivers of information recorded on a textbook page or handed down by a teacher. The Standards call for students to become active participants in their own learning process, with teachers working as facilitators and coaches.

Our goal is to provide you with sound activities that will supplement your curriculum and help you integrate technology into your classroom. The activities have been field tested by a cross section of teachers from around the country. Some of the activities are more basic; other activities are more challenging. We don't expect that every teacher will use every activity. You choose the ones you need for your educational objectives.

Teacher's Guide

We suggest you take a few minutes to look through this Teacher's Guide to familiarize yourself with its features.

Each lesson follows the same format. The first page provides an overview of the activity, learning objectives, a list of materials, and a glossary of important terms. The next two pages present a lesson plan in three parts: ENGAGE, EXPLORE, and EVALUATE.

- ENGAGE presents discussion questions to get the students involved in the topic. Video clips from the *Newton's Apple* segment are integrated into this section of the lesson.
- EXPLORE gives you the information you need to facilitate the student activity.
- EVALUATE provides questions for the students to think about following the activity. Many of the activities in the collection are open-ended and provide excellent opportunities for performance assessment.

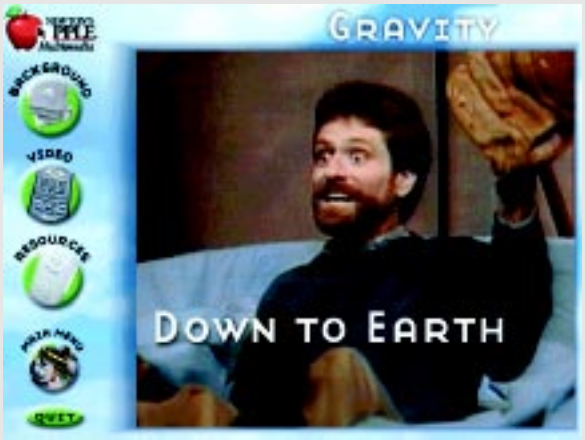
GUIDE ON THE SIDE and TRY THIS are features that provide classroom management tips for the activity and extension activities.

USING THE CD-ROM

When you run the *Newton's Apple* CD-ROM, you will find a main menu screen that allows you to choose either of the two *Newton's Apple* topics or the scientist profile. Simply click on one of the pictures to bring up the menu for that topic.

Main Menu

Once you have chosen your topic, use the navigation buttons down the left side of the screen to choose what information you want to display.



Topic Menu

The Background button brings up a short essay that reviews the basic science concepts of the topic. This is the same essay that is in the Teacher's Guide.

Playing the Video

The Video button allows you to choose several different clips from the video segment. We have selected short video clips to complement active classroom discussions and promote independent thinking and inquiry. Each video begins with a short introduction to the subject that asks several questions. These introductory clips can spark discussion at the beginning of the lesson. The Teacher's Guide for each activity presents specific strategies that will help you engage your students before showing the video. Each of the individual clips are used with the lesson plans for the activities. The lesson plan identifies which clip to play with each activity.

Video Menu

Once you select a video and it loads, you'll see the first frame of the video segment. The video must be started with the arrow at the left end of the scroll bar. As you play the video, you can pause, reverse, or advance to any part of the video with the scroll bar. You can return to the Clips Menu by clicking on the Video button.

Multimedia Tools

The *Newton's Apple* staff has designed a product that is flexible, so that you can use it in many different ways. All of the video clips used in the program are available for you to use outside the program. You may combine them with other resources to create your own multimedia presentations. You will find all the video clips in folders on the CD-ROM. You may use these clips for classroom use only. They may not be repackaged and sold in any form.

You will also find a folder for UGather™ and UPresent™. These two pieces of software were developed by the University of Minnesota. They allow you to create and store multimedia presentations. All of the information for installing and using the software can be found in the folder. There is an Adobe Acrobat® file that allows you to read or print the entire user's manual for the software. We hope you will use these valuable tools to enhance your teaching. Students may also wish to use the software to create presentations or other projects for the class.

Technical Information

Refer to the notes on the CD-ROM case for information concerning system requirements. Directions for installing and running the program are also provided there.

Make sure you have the most current versions of QuickTime® and Adobe Acrobat® Reader installed on your hard drive. The installation programs for QuickTime 3, QuickTime Pro, and Acrobat Reader 3.0 can be found on the CD-ROM. Double-click on the icons and follow the instructions for installation. We recommend installing these applications before running the *Newton's Apple Multimedia* program.

Trouble Shooting

There are several Read-Me files on the CD-ROM. The information found there covers most of the problems that you might encounter while using the program.

Integrating Multimedia

We suggest that you have the CD-ROM loaded and the program running before class. Select the video and allow it to load. The video usually loads within a couple of seconds, but we recommend pre-loading it to save time.

All of the video segments are captioned in English. The captions appear in a box at the bottom of the video window. You can choose to play the clips in either English or Spanish by clicking one of the buttons at the bottom right of the screen. (You can also choose Spanish or English soundtracks for the scientist profile.)

The Resources button provides you with four additional resources. There are additional video clips, charts, graphs, slide shows, and graphics to help you teach the science content of the unit.

Resources Menu

The other navigation buttons on the left side of the window allow you to go back to the Main Menu or to exit the program.

Take Your Medicine

How do antibiotics work? Why doesn't one antibiotic work for every disease? Why won't antibiotics cure a cold? Where do antibiotics come from?

Themes and Concepts

- health
- microorganisms and drugs
- diversity and adaptation of reproduction and heredity in organisms

National Science Education Content Standard

Content Standard A: Students should develop abilities necessary to do scientific inquiry.
Content Standard C: Students should develop an understanding of strucure and function in living systems.
Content Standard F: Students should develop an understanding of personal
health.

Activities

1. *Bacteria Galore—Approx. 60 min. prep; 90 min. class time (2 class periods)*
Where do bacteria come from? Why are there so many of them, and what do bacteria look like? Students make and sample yogurt. They then observe yogurt bacteria under a microscope and estimate the number of bacteria they have consumed.

2. *Antibiotic Power—Approx. 15 min. prep; 10-15 min. class time over several days*
Do antibiotics work well against all bacteria? Which topical antibiotics are the best? Students see for themselves as they fight bacterial cultures with over-the-counter antibiotics.

3. *Germ Wars—Approx. 20 min. prep; 95 min. class time*
Students participate in a game of "Bacterial Invaders." They become part of the action as they take the roles of antibiotics, bacteria, and points of entry into the body.

More Information

Internet

Newton's Apple
http://www.ktca.org/newtons
(The official *Newton's Apple* web site with information about the show and a searchable database of science ideas and activities.)

American Society for Microbiology
http://outcast.gene.com/ae/RC/ASM
(Vendors of biological supplies; teacher/scientist network; activity exchange.)

Centers for Disease Control and Prevention—National Center for Infectious Diseases
http://www.cdc.gov/ncidod.htm

Microbe Zoo
http://www.microbezoo.com
(Lesson plans from the Microbe Zoo CD-ROM.)

Internet Search Words

bacteria
antibiotics
microorganisms
microbiology
microbe

Books and Articles

Begley, S. "Antibiotics: The end of miracle drugs?" *Newsweek*, 46-51, 1994. (Cover story and two related articles.)

Braffman-Miller,J. "Beware the rise of antibiotic-resistant microbes." *USA Today* (March):56, 1997. (Discusses the public health hazard of antibiotic-resistant bacteria.)

Dashefsky, H.S. *Microbiology: 49 science fair projects.* New York: TAB Books, Division of McGraw-Hill, Inc., 1994. (Experiments with microbes.)

DeKruif, Paul. *Microbe Hunters.* New York: Harcourt Brace, 1996. (Well-written source for young people.)

Levy, Stuart B. *The Antibiotic Paradox: How Miracle Drugs Are Destroying the Miracle.* New York: Plenum Press, 1992. (The over use of antibiotics is discussed.)

Video

Bacteria.
14 minutes, with teachers' guide.
Chicago: Clearvue/eav
(Up-to-date information on bacteria.)

Software

Viruses and Bacteria.
CD-ROM/Macintosh & Windows.
Chicago: Clearvue/eav
(Up-to-date information on bacteria.)

Community Resources

Microbiology laboratory at a hospital or clinic

Biology department at a local college university

Background

What's going around at your school lately? A nasty cold? Strep throat? There always seems to be something out there waiting to get you. Contagious illnesses are caused by many different types of germs. Colds and many sore throats are caused by viruses, but bacteria are responsible for illnesses such as strep throat and pink eye.

If you've gone to the doctor with a sore throat, a medical technician probably took a throat culture to identify the germs causing your illness. If a bacterium, the germ streptococci, was the culprit, you were probably given antibiotics to kill the germs. Modern medicine does not have drugs to cure most viral illnesses, but antibiotics can cure bacterial infections.

The smallest, most ancient, and perhaps most numerous of free-living organisms, bacteria are neither plant nor animal. We carry billions of these one-celled organisms around with us on our skin, in our mouths and noses, and throughout our bodies. They are in water, food, and soil, and on almost every surface we touch. Fortunately, most bacteria are helpful, or at least harmless, to humans. Some, for example, break down decaying materials, and others are necessary for producing certain foods. We also use the bacteria living inside our bodies to help digest our food.

But some bacteria can cause disease, and antibiotics are the big guns against many of the harmful ones. Most antibiotics come from molds or bacteria that have produced chemicals that kill or stop the growth of other types of bacteria. Also, researchers have managed to create antibiotics in the lab that work in similar ways. But bacteria have not remained entirely defenseless against the onslaught of antibiotics. One bacterium can produce millions of cells in one day, so the odds are that some bacteria will have created mutations that are resistant to antibiotics. The more a particular antibiotic is used, the greater the chance of a bacterial mutation that would cause antibiotic resistance. Taking antibiotics for a cold won't help you get better, but it does create an opportunity for antibiotic resistance to develop in the bacteria in your body.

You should take all of the antibiotics that are prescribed, even if you feel better before the medicine is gone. If you stop taking the medicine, the bacteria left in your body might make you sick again. The last of the bacteria to die might be the most drug-resistant ones, and stopping your medicine too soon not only leaves the most resistant ones alive, it also leaves your body open to a rapid growth of the resistant strain.

So, as your grandmother always told you, listen to your doctor and take your medicine—all of it!

Video & Stills

Video Segments

Introduction

1:43:57 to 1:44:29—Newton's Apple host Dave Huddleston poses some questions about bacteria, viruses, and antibiotics. (32 sec.)

Video Clip 1

1:44:30 to 1:46:42—Dr. Margaret Hostetter answers David Heil's questions and provides interesting facts about bacteria. (2 min. 12 sec.)

Video Clip 2

1:46:43 to 1:47:44—David Heil observes a cell from his mouth under the microscope. (1 min.)

Video Clip 3

1:47:44 to 1:50:24—David Heil fights off invading bacteria in "Bacterial Invaders." (2 min. 40 sec.)

Video Clip 4

1:50:33 to 1:51:41—Dr. Margaret Hostetter explains where antibiotics come from. (1 min. 8 sec.)

Multimedia Resources

Button A

Photomicrograph of bacteria cells.

Button B

Photomicrograph of a virus.

Button C

Newton's Apple video clip of bacterial action in sewage processing

Button D

Chart showing various antibiotics and the diseases on which they are effective.

Unit Assessment Answer Key

The Unit Assessment on the following page covers the basic concepts presented in the *Newton's Apple* video segment and the Background section of this guide. The assessment does not require completing all of the activities. The Unit Assessment may be used as a pre- or post-test. However, students should view the complete *Newton's Apple* video before doing this assessment. There is additional assessment at the end of each activity.

Think about it

1. Some bacteria will not have been killed by the pasteurization process; other bacteria may have entered the milk from the air. These bacteria reproduce and sour the milk.
2. Different bacterial diseases are caused by different types of bacteria, not all of which are susceptible to the same antibiotics.
3. All the illness-causing bacteria may not be killed by only part of a prescription, and these bacteria could cause the patient to get sick again. Not finishing the antibiotics could also contribute to the production of antibiotic-resistant bacteria.
4. The chemical was produced by bacteria which were competing for food and space, and it destroyed or interfered with the growth of other types of bacteria. When this chemical is isolated from the bacteria that produces it, it continues to provide an effective means of eradicating those competing bacteria.
5. Through mutation, bacteria could develop some kind of defense which makes them antibiotic-resistant.

What would you say?

6. d 7. a 8. c 9. c 10. b

NEWTON'S APPLE Multimedia

Unit Assessment

What do you know about Antibiotics?

Write the answers in your journal or on a separate piece of paper.

Think about it

1. The milk we buy in a store has been pasteurized to destroy bacteria. But even pasteurized milk will eventually sour. Why?

2. Why is more than one kind of antibiotic needed?

3. Why should you take all of the antibiotics that your doctor prescribed even if you feel better before you have taken it all.

4. Bacitracin, an antibiotic commonly used in cream for wounds, was first discovered in 1945 in the bacteria of an infected wound. Explain how a chemi cal found in bacteria in a wound could help fight infection in a wound.

5. What could cause an antibiotic to lose its ability to kill a particular kind of bacteria?

What would you say?

6. Bacteria grow in or on—
   a. food.
   b. our skin.
   c. dirt.
   d. all of the above

7. Antibiotics are often produced by—
   a. bacteria.
   b. viruses.
   c. rocks.
   d. animals.

8. Which of the following body parts is not an entryway for bacteria to get into our body?
   a. mouth
   b. nose
   c. hair
   d. open wounds

9. A mutation is a—
   a. defect in a living organism.
   b. chemical that fights off antibiotics.
   c. change in an organism inherited by its offspring.
   d. process by which an organism reproduces.

10. Antibiotics are not effective against the common cold because—
    a. the mucus produced by a cold neutralizes antibiotics.
    b. colds are caused by viruses, which are not affected by antibiotics.
    c. colds are produced by antibiotic-resistant bacteria.
    d. in a cold, the bacteria reproduce too rapidly for an antibiotic to be effective.

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Activity 1

Bacteria Galore

What are bacteria? Where do they grow and what do they look like? How big are they? How many kinds of bacteria are there? Are there bacteria that help us?

Getting Ready

Overview

Students prepare yogurt, sample it, and then observe yogurt bacteria under a microscope. They use data from their observations to estimate the number of bacteria they have eaten.

Objectives

After completing this activity, students will be able to—

- explain how bacteria can be used in useful ways
- calculate a bacterial population
- understand the consequences of bacterial reproduction
- identify bacteria under a microscope

Time Needed

Preparation: approximately 60 minutes
Classroom: approximately 90 minutes (two separate days)

Materials

Each team of students:

- dishwashing liquid
- 1 qt of milk
- 5 grams of freeze dried yogurt starter or 1.5 ml of plain yogurt with active yogurt culture
- medium size pan and a stirring spoon
- 4-oz baby food glass jar with a lid (for each student)
- stove and sink
- large picnic cooler(s)
- thermometer for each picnic cooler
- plastic spoons and paper cups
- honey or fruit preserves for sweetening yogurt
- microscope
- 2 microscope slides
- coverslip
- methylene blue stain
- clean toothpick

Important Terms

bacteria — One-celled microorganisms that are found in soil, water, plants, and animals. Some parasitic forms cause infectious disease.

culture — A growth or colony of living cells or microorganisms in a controlled artificial environment.

incubate — To grow or develop an organism at optimal conditions, including temperature.

reproduce — To generate offspring.

Antibiotics

Here's How

Video Clip 1
1:44:30 to 1:46:42—Dr. Margaret Hostetter answers David Heil's questions and gives some interesting facts about bacteria. (2 min. 12 sec.)

Preparation

- Set up the computer to play the CD-ROM (or set up the VCR and cue the tape).
- Gather the materials for each team of students.
- Make a copy of Activity Sheet 1 for each student.
- Review the information in the Background on page 8.

Guide on the Side

- You may wish to begin the lesson by viewing the Introduction from the Video Menu on the CD-ROM [1:43:57 to 1:44:29]. Find out what students already know about antibiotics and microbes. As a class, discuss the questions posed by David Huddleston.
- When calculating the total money in the doubling scenario, students may forget to add in the previous day's amount. For example:
day 1=$0.01,
day 2=$0.02+$0.01,
day 3=$0.04 +$0.03, etc.
- Yogurt must be kept cool after ten hours. Refrigerate the students' yogurt or have someone resupply the cooler with ice in the evening.
- Many science classrooms have a no-food rule. Have students eat their yogurt in an appropriate place.
- Be sure to warn students that methylene blue stains clothing and skin. Students should follow established lab safety procedures.
- Students may require some assistance identifying the bacteria, and estimating the bacterial count. The bacteria look like chains of tiny circles or spheres. The 100x view is the minimum magnification required to see the bacteria. A higher magnification is better.
- If time allows, you may wish to view the *Newton's Apple* video segment on antibiotics after completing the activity.

Engage (Approx. 15 minutes)

Ask your students if any of them have ever been to a doctor with a sore throat. Did the doctor tell them they had a viral infection or a bacterial infection? Most sore throats are viral infections, but some are caused by bacteria. Show the photomicrographs of bacteria and a virus—Resource buttons A and B on the CD-ROM. Explain that bacteria cause many diseases, but there are also "good" bacteria that we could not get along without. Bacteria in the human body help us digest food, for example. Ask students if they know of any foods that cannot be produced without bacteria. (Yogurt, cheese, and sour cream are a few.)

Show Video Clip 1 [1:44:30 to 1:46:42]. David Heil and Dr. Margaret Hostetter discuss bacteria. Be sure students understand what bacteria are and where they live. Ask students if anyone has ever seen bacteria. Explain that a single bacterium can only be seen through a microscope, but colonies of bacteria and the effect of bacteria can be observed without a microscope. For example, bacteria infecting the respiratory system can turn the mucus green. Spoiled milk smells and tastes sour.

Ask students whether they would rather be given $10 a day for one month, or one penny the first day of a month and double that amount on the next day with subsequent doubling every day for the whole month. After students have chosen, ask them if they'd rather have $300 or $10,737,418. Have students do the math to verify this amount. Ask students how fast a single bacterium could develop into 10,737,418 new bacteria if each offspring divided every minute and none died. (It would take a half hour.) Ask them what they think keeps bacteria from taking over the world at this rate of reproduction. Accept all answers.

Activity 1

Explore (Approx. 40 minutes)

Day 1 Tell students that they are going to use bacteria to produce a popular food—yogurt. Review safety rules for using a stove or other lab equipment. Tell students they will need to heat one quart of milk almost to boiling. Next, they remove the milk from the heat and cool it until it is lukewarm. While waiting for the milk to cool, students should wash their jars with hot, soapy water and rinse them well. Students then stir 5 grams of yogurt starter or 1.5 ml of plain yogurt with active yogurt cultures into the milk. Next, students pour the milk into the jars, cap the jars, and place them in a picnic cooler that contains enough warm water (42° C to 44° C) to reach at least half the height of the jars. The temperature will have to be kept constant for about 10 hours while the culture incubates. Then the jars may be placed in a refrigerator or a cooler with ice.

Day 2 Provide spoons, paper cups, and sugar, honey, or fruit preserves for the students to sample their yogurt. Have students save a small (a drop or two) unsweetened sample for viewing under the microscope.

Tell the students that they are going to get a close-up look at what they have just eaten. Show them how to make a slide of their yogurt culture. Tell them to put a very tiny amount of yogurt on a slide with the end of a toothpick, and then add one drop of water to it, using an eye-dropper. Smear the yogurt over one half of the slide, using the end of another slide to make a thin layer. Tell students to let the yogurt dry, and then put two drops of methylene blue on it. After two minutes, have them rinse the slide with a slowly dripping faucet, and place a coverslip on the slide.

Students should observe the bacteria under all magnifications of their microscopes. Help them make a rough estimate of the number of bacteria in a serving of yogurt. First, estimate the number of bacteria seen in a 100x field view. If the area of a 100x field view is 3.14 mm^2, and if students spread their drop of yogurt over one half the slide, then they are viewing about 1/258 of the total bacteria on the slide. Students need to multiply the number of bacteria they counted by 258 to approximate the number of yogurt bacteria in one "toothpick drop" on the slide. If each student ate one 4-oz jar of yogurt, they will have eaten about 118 ml of yogurt. If there are 50 "toothpick drops" of yogurt in a milliliter, they can estimate how many bacteria were in a serving.

Evaluate

1. What are some useful purposes for bacteria? (Bacteria help produce certain foods, such as cheese and yogurt; help break down organic matter; and help people digest food.)

2. Describe the size and appearance of the bacteria you observed. (The bacteria are one-celled organisms that are circular in shape. Thousands of them could fit on the head of a pin. Several bacteria attach together to form chains.)

3. How would the population of bacteria change after two weeks of incubation? Why? (The number of bacteria would increase, because warmth encourages bacteria to multiply. The number would decrease if there wasn't a nutrient supply.)

Try This

Find out which bacteria live in or on the human body and are necessary for our survival. What do these bacteria do that helps us?

View the video clip found at Resource Button C on the CD-ROM. Investigate how bacteria are used to clean up oil spills and toxic wastes, or how they produce insulin and bio-plastics. What natural process allows these microbes to do what they do?

Interview someone who cans their own food. Ask them what types of precautions they take against botulism, a deadly disease caused by a type of bacteria found in poorly sterilized canned foods.

Find out how bacteria are important in composting. Measure the temperature inside a compost heap. Find out what causes the temperature to rise. Set up a compost heap at home. How is composting helpful to the environment?

Collect a sample of pond water or meltwater from snow. Use an eye dropper to place four or five drops of water on a slice of bread. Lightly wrap the bread in plastic wrap and leave it a warm place for 48 hours. You'll have lots of mold and bacteria growing on the bread. Scrape the bread and examine the scrapings under a microscope. The fungi will look very fuzzy. The bacteria are typically smoother. What other differences can you observe. Report your findings to the class.

Bacteria Galore

Activity Sheet 1

Name _____ Class Period _____

What you're going to do

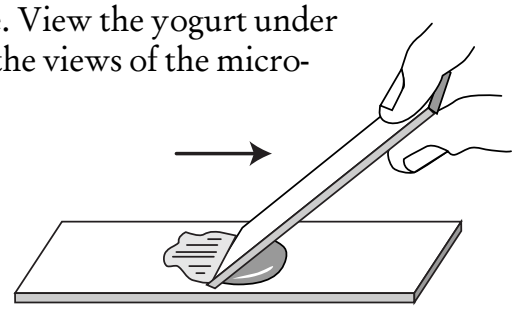
You're going to make your own yogurt and sample it. You are also going to examine the yogurt culture under a microscope and make a rough estimate of the number of yogurt bacteria you have eaten!

How to do it

1. Work with your group. Heat a quart of milk until it is almost boiling. Remove the milk from the heat and allow it to cool until it is lukewarm. Then stir in 5 g of yogurt starter or 1.5 ml of plain yogurt with active yogurt cultures.

2. Pour the warm milk into jars, cap the jars, and place them in a picnic cooler that contains enough warm water (42° C to 44° C) to cover at least half the height of the jars. The temperature will have to be kept constant for about 10 hours. Then the jars may be placed in refrigerator or a cooler with ice.

3. The following day, sample the yogurt. Save a small, unsweetened portion for observation under a microscope. Prepare a slide of the yogurt culture. With the end of a toothpick, put a very tiny amount of yogurt on a glass slide. Add one drop of water to it using an eyedropper. Smear the yogurt over one half of the slide, using the end of another slide to make a thin layer. Let the yogurt dry, and then put two drops of methylene blue on it. After two minutes, rinse the slide under a slowly dripping faucet, and place coverslip on the slide. View the yogurt under each of the views of the microscope.



Recording your data.

In your journal, calculate the number of bacteria in a serving of yogurt.

Estimate the number of bacteria you can see in a 100x field view. If the area of

a 100x field view is about 3.14 mm^2, and if you spread a drop of yogurt over one half the slide, then you are viewing about 1/258 of the total bacteria on the slide.

Multiply the number of bacteria you counted by 258 to approximate the number of yogurt bacteria in one toothpick-drop. If you ate one 4-oz jar of yogurt, you will have eaten about 118 ml of yogurt. If there are 50 toothpick drops of yogurt in a milliliter, you can estimate how many bacteria were in the serving of yogurt.

What did you find out?

Why do you suppose the milk had to be heated?

Why was it necessary to add yogurt culture or plain yogurt to the warm milk?

Why do you suppose it is necessary to incubate the warm milk?

What changes did you observe in your yogurt after it had incubated overnight?

What might be a reason that the actual number of bacteria you consumed is larger or smaller than you calculated?

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Activity 2

Antibiotic Power

How do antibiotics work? Why do you need different antibiotics for different illnesses? Why don't antibiotics always work? Do antibiotics only kill bacteria?

Getting Ready

Overview

Students culture bacteria from their mouths and compare the effectiveness of over-the-counter topical antibiotics in inhibiting bacterial growth.

Objectives

After completing this activity, students should be able to—

- culture bacteria
- identify physical characteristics of a bacterial colony
- observe and compare the action of antibiotics on bacteria
- set up a controlled experiment

Time Needed

Preparation: approximately 15 minutes
Classroom: approximately 45 minutes

Materials

Available to all students:

- several different over-the-counter topical antibiotics
- several different over-the-counter nonantibiotic first-aid creams

For each pair of students:

- sterile blood agar plate
- cotton swabs
- adhesive tape and marker
- ruler
- plastic bags for disposal of contaminated swabs
- latex or surgical gloves (optional)

Important Terms

antibiotic — A compound that kills or inhibits the growth of a microorganism, primarily bacteria. Antibiotics are not effective against viruses.

colony — A group of living organisms.

fungus — A living organism in the fungi kingdom, which includes molds, yeasts, and mushrooms. Fungi have a fuzzy appearance in a culture.

inoculate — To introduce microorganisms, such as bacteria, into a nutrient medium to start a new culture.

pathogen — A disease-causing organism, such as a bacterium or virus.

zone of inhibition — An area of a bacterial culture in which there is no bacterial growth, due to the presence of compounds that destroy bacteria or prevent growth.

Antibiotics

Here's How

Video Clip 2
1:46:43 to 1:47:44—David Heil observes a cell from his mouth under the microscope. (1 min.)

Preparation
- Set up the computer to play the CD-ROM (or set up the VCR and cue the tape).
- Gather the materials for each team of students.
- Make a copy of Activity Sheet 2 for each student.
- Review the information in the Background on page 8.

Guide on the Side

- You may wish to begin the lesson by viewing the Introduction from the Video Menu on the CD-ROM [1:43:57 to 1:44:29]. Find out what students already know about antibiotics and microbes. As a class, discuss the questions posed by Dave Huddleston.
- Remind students to keep the lids on their plates.
- Students may wear latex or surgical gloves if they are available.
- Be sure students have labeled all plates and taped them shut before the plates are incubated.
- Triple Antibiotic Ointment® is effective against most bacterial types. If you are using only one cream type, this might be a good one to choose.
- If time allows, you may wish to view the *Newton's Apple* video segment on antibiotics after completing the activity.

Engage (Approx. 15 minutes)

Ask students if they have ever taken or used an antibiotic. Did it work or not? Was the prescription changed, and did the new antibiotic make them well? Show Video Clip 2 [1:46:43 to 1:47:44]. Ask students why all bacteria can't be destroyed with the same antibiotic. Ask them why an antibiotic prescription sometimes has to be changed.

Ask students what might be the proper way to treat a small cut or scrape. Ask them what soap and water does to a wound. Do they use a topical ointment? What kind do they used? Which do they prefer and why? If no students bring up antibiotic ointments, ask them how they think an antibiotic ointment would compare to other types of ointments. Accept all answers.

Explore (Approx. 45 minutes)

Tell students that they will be culturing bacteria taken from their mouths. Demonstrate the process of inoculating an agar plate. Rub a clean cotton swab over your gumline, then open an agar plate and gently zigzag the cotton swab across the agar surface, from one side to the other. Tell students to take care and not tear the agar surface. Use another clean swab to dab a small amount of antibiotic cream on one side of the agar plate. Then with a third clean cotton swab, dab the same amount of nonantibiotic first-aid cream on the other side of the plate. Dispose of the swabs properly.

Explain that once students inoculate the plates, they need to close and tape the lids shut. Emphasize that they should not reopen the lids, because some pathogenic bacterial cultures might be growing. Have students label the lid of the plate with their name. They should also mark the location and type of each cream.

Collect inoculated plates and store them in an incubator or under an incandescent light. Plates should be inverted before storage, to prevent condensation of water from ruining the bacterial colonies. Have students wash their hands well with hot, soapy water.

Activity 2

Have students record daily observations of their cultures in their journals. A colony of bacteria will appear as a spot on the agar, while fuzzy spots will indicate fungi. Different bacterial colonies will have different characteristics. Have students observe color, shininess, dullness, and texture. If the bacterial colonies growing on a plate are susceptible to the antibiotic in the cream, there will be a zone of inhibition around the antibiotic. Once these zones become obvious, have students measure the zones by placing a metric ruler on the lid of the plate and measuring from the edge of the cream to the outer edge of the zone. Have students record this information in their journals.

Remind students to wash their hands with hot, soapy water after any observation. After their final observations (about one week), compare zones of inhibition. If students have used different antibiotic creams, have them compile and compare the class data. Which antibiotic appears to be the most effective? Which nonantibiotic first-aid cream appears to be most effective? Have students follow your school's established policies for disposal of possible pathogenic material.

Evaluate

1. Why was it necessary to use a non-antibiotic cream in this activity? (The non-antibiotic cream served as a control in the experiment.)

2. Compare your bacterial culture with other students' cultures. How many different types of bacteria did you observe? What characteristics did you observe? (Characteristics may include color, texture, shininess, etc.)

3. In addition to the bacterial colonies, were any fungi colonies present on your agar plates? (Fungus spores, like bacteria, seem to be everywhere. You may have introduced them to your plate with your cotton swab or from the air that came in contact with the agar.) How effective were the antibiotics against them? (Antibiotics are not effective against fungi.)

Try This

Investigate how drugs are discovered, developed, and produced. What must a company do to get a new drug approved for general use? How long does this process take? What kind of testing must be done? Are generic drugs as good as name-brand products?

Which cutting boards are cleaner—wood or plastic? Devise an experiment in which you culture bacteria from both kinds of boards, and draw your own conclusions. Investigate the best way to kill undesirable bacteria on cutting boards. Which works better—soap and water or drying in the sun? (Wash your hands well after handling the cutting boards.)

Invite a microbiologist or a medical technologist to explain what antibiotics are and how they work. Examine equipment from the lab, discuss different kinds of bacteria, and ask about the tests that identify bacteria.

Interview the school dietitian about what measures are taken in your school to limit bacteria from getting into school lunches. Find out how the dishes are washed and stored. Ask what hygiene is required of the servers. How does the way they store food limit bacterial growth?

NEWTON'S APPLE Multimedia

Antibiotic Power

Activity Sheet 2

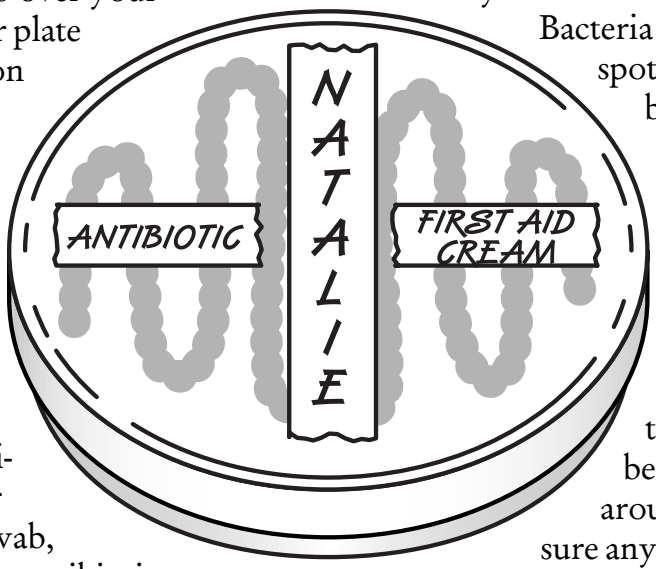
Name _____ Class Period _____

What you're going to do

You're going to see how antibiotics kill germs! First, you'll culture bacteria from your mouth. Then you'll compare how an antibiotic cream and a nonantibiotic first aid cream work.

How to do it

1. Rub a clean cotton swab over your gumline, then open an agar plate and gently zigzag the cotton swab across the agar surface. Dispose of the swab properly.



2. Choose one antibiotic cream or ointment and one nonantibiotic first aid cream. Use another clean swab and dab a tiny amount of the antibiotic on one side of the agar plate. With a third clean swab, dab the same amount of nonantibiotic first aid cream on the other side of the plate. Dispose of the swabs properly. Cover the agar plate, and seal it with tape. Label the lid with your name. Mark the location and type of the two creams. Wash your hands well with warm, soapy water.

3. Check your agar plate every day. Record your observations in your journal. Bacteria colonies will appear as spots on the agar. Different bacterial colonies will have different characteristics; look for color, shininess, dullness, and texture. Record your observations. If the bacterial colonies growing on the plate are susceptible to the antibiotic, there will be a zone of inhibition around the antibiotic. Measure any zones of inhibition daily, by placing a ruler on the lid of the plate. Measure from the edge of the cream to the outer edge of the zone. Fungi may also appear as a fuzzy spot. Record information about any fungi you observe.

What did you find out?

Describe the characteristics of the bacteria and fungi you observed on your agar plate.

Compare the bacterial growth on your agar plate with that of your classmates. Can you observe any differences? What might account for any differences?

Compare zones of inhibition. Which antibiotic appears to be the most effective? Which nonantibiotic first-aid cream appears to be most effective?

Record your data

Set up a data table in your science journal and record your observations. Include the following information:

Antibiotic cream. _____

Nonantibiotic cream. _____

Size of inhibition zone:

Day One: _____ Day Four: _____

Day Two: _____ Day Five: _____

Day Three: _____ Day Six: _____

Other observations: _____

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Activity 3

Germ Wars

How do bacteria get inside your body? How do just a few bacteria cause a huge infection? Why do you have to take an entire prescription, even if you feel fine before you've taken all the pills? How can some bacteria survive antibiotics?

Getting Ready

Overview

Students take roles and model the action of bacteria in a game of "Bacterial Invaders." Other students represent dosages of antibiotics who try to eradicate the susceptible bacteria.

Objectives

After completing this activity, students will be able to:

- explain how antibitotics work in the human body
- describe the effect of antibiotic-resistant bacteria on a population
- explain the importance of completing a course of antibiotics.

Time Needed

Preparation: approximately 20 minutes
Classroom: approximately 90 minutes

Materials

- stopwatch
- whistle
- 49 index cards
- three 8.5" x 11" sheets of paper
- 3 pieces of string about 50 cm long

Important Terms

genetic mutation — A process by which a cell's genetic makeup is altered. A mutation can produce bacteria that is resistant to antibiotics.

point of entry — The ways or locations in which microorganisms can enter the body. They include the nose, the mouth, and wounds.

reproduction — The process by which living things generate offspring.

resistance — The natural or acquired characteristic of a bacterium to escape the effects of an antibiotic.

strain — A subtype of bacteria within a species. A strain of bacteria has characteristics that differentiate it from the main species and other strains.

Antibiotics

Here's How

Video Clip 3
1:47:44 to 1:50:24—David Heil fights off invading bacteria in "Bacterial Invaders." (2 min. 40 sec.)

Video Clip 4
1:50:33 to 1:51:41—Dr. Margaret Hostetter explains where antibiotics come from. (1 min. 8 sec.)

Guide on the Side

- You may wish to begin the lesson by viewing the Introduction from the Video Menu on the CD-ROM [1:43:57 to 1:44:29]. Find out what students already know about antibiotics and microbes. As a class, discuss the questions posed by Dave Huddleston.
- If the area representing the human body is too large, students may not be able to tag each other quickly enough during the allotted time.
- After you have gone over the rules of the game, run one or two practice rounds to make sure everyone understands what to do.
- A smaller playing area may allow the game to move more quickly.
- The game may also include a round in which the bacteria are labeled "antibiotic-resistant mutating bacteria." The round would be similar to round four in which all of the bacteria survive.
- If time allows, you may wish to view the *Newton's Apple* video segment on antibiotics after completing the activity.

Preparation
- Set up the computer to play the CD-ROM (or set up the VCR and cue the tape).
- Gather the materials for each team of students.
- Make a copy of Activity Sheet 3 for each student.
- Review the information in the Background on page 8.

Engage (Approx. 15 minutes)

Ask students to recall a time they took antibiotics. Did the antibiotic make them well? Did a doctor ever change a prescription of antibiotics for them? Why? Show Video Clip 3 [1:47:44 to 1:50:24] in which David Heil fights off invading bacteria. Ask students why David's ammunition worked sometimes, but not always.

Have your students compare football players to bacteria and antibiotics. For example, what would happen if two teams were equally matched? What if one coach sent in all second- or third-string players for the second half of the game? Ask students to consider how this might be similar to taking half a course of antibiotics. Show Video Clip 4 [1:50:33 to 1:51:41] and discuss the consequences of not completing a course of antibiotics.

Explore (Approx. 80 minutes)

Tell your students they are going to play "Bacterial Invaders." Have students make the bacterium and antibiotic cards and the signs for the nose, mouth, and wound.

Bacterial Invaders—The Classroom Game: Bacterial Invaders is a modified game of tag that models the behavior of bacteria and antibiotics in the human body. The object of the game is for the "antibiotic" players to overcome the "bacteria" and make the body well.

The Players: Students play the roles of antibiotics and bacteria, as well as the entry points for bacteria into the body: the mouth, the nose, and a wound. The mouth also represents the entry point for dosages of antibiotics. The teacher is the timekeeper and the referee in the game.

Preparation: Antibiotic and Bacterium Identification: Write "bacterium" on 37 cards and "antibiotic" on 12 cards. Fold the cards in half. Arrange them in six sets containing 5 bacterium cards and 2 antibiotic cards, and one set consisting of seven bacterium cards.

Playing Area: Select a gymnasium or other large, open space for the playing area. Indicate that about two-thirds of the room represents the human body. Place a chair or small table at the back part of the "body" where students will leave their bacterium and antibiotic cards after each round of the game. Students playing bacteria and antibiotics wait in line to enter the body.

Mouth, Nose, and Wound Identification: Label three sheets of 8.5" x 11" paper "mouth," "nose," and "wound." Attach strings to the sheets so that three students can wear the signs around their necks.

Set Up: Choose three students to represent the nose, the mouth, and the wound, and have them stand evenly spaced across the entrance to the playing area "body." The remaining students—bacteria and antibiotics—wait in lines at the mouth, nose, and wound to enter the body.

Activity 3

How to Play The game is divided into seven rounds.
Round One: The first round begins when the teacher gives out one set of cards: the nose gets two bacterium cards; the wound gets two bacterium cards; and the mouth gets one bacterium card and two antibiotic cards. Then the teacher blows a whistle, and starts the stopwatch. The mouth, nose, and wound hand their cards to the first students in their lines, allowing them to enter the body.

Inside the "body," students chase and tag each other. When one student tags another, both students unfold their cards and reveal their roles to each other. When students with the same kind of card tag each other, they fold their cards and continue playing the round. When a bacterium and an antibiotic tag each other, the antibiotic wins. The defeated bacterium student is out of the round, gives the bacterium card to the teacher, and gets in line to enter the body again in a subsequent round. The antibiotic students play out the rest of the round.

The teacher signals the end of a round after 15 seconds. At the end of the round, students remaining in the body put their cards (bacterium or antibiotic) on the chair in the body and get back in line to enter the body again.

Subsequent Rounds: The procedure for the other rounds is the same as it is for the first round. The teacher gives out a set of bacterium and antibiotic cards to the mouth, nose, and wound, and signals the beginning of the round. An exception is round four.

Round Four: The teacher distributes to the mouth, nose, and wound the set of cards that consists only of 7 bacterium cards. Students should not be made aware of the difference in this round. Because there are no antibiotic cards, the number of bacteria in the body do not decrease during the third round, illustrating the effect of a discontinuation of antibiotics. The procedure for playing the round is the same as the other rounds.

Deciding the Winner: The game ends after seven rounds. At the end of the last round, count the bacterium and antibiotic cards on the chair. The group with the most cards wins the game.

Evaluate

1. How do bacteria enter your body? (Through the nose, mouth, or an open wound.)

2. Why can't one antibiotic pill make you well? (Bacteria are able to multiply too quickly for only one antibiotic dosage to be effective.)

3. What is a model? How can scientists use a model like the game to explore science questions?

Try This

About 40% of antibiotics used in the United States are not for humans. Explore the use of antibiotics with livestock. Speculate on the implications of this practice in the development of antibiotic-resistant strains of bacteria, and how these strains might be passed on to humans.

Different bacteria are susceptible to different antibiotics. Show the chart found at Resource Button D on the CD-ROM. Ask a pharmacist for inserts from commonly prescribed antibiotics, such as penicillin, or tetracycline. Find out what types of bacteria are affected by those particular antibiotics. Compare the antibiotics. Are there bacteria types that can be destroyed by more than one antibiotic?

Germ Wars

Activity Sheet 3

Name _____ Class Period _____

What you're going to do

You're going to learn about the behavior of bacteria and antibiotics by playing "Bacterial Invaders!"

How to do it

Bacterial Invaders—The Classroom Game

Bacterial Invaders is a special game of tag that models the behavior of bacteria and antibiotics in the human body.

The Players You and your classmates play the roles of antibiotics and bacteria, and the entry points for bacteria into the body—the mouth, thezx nose, and a wound. The mouth also represents the entry point for dosages of antibiotics.

Preparation Set up the playing area according to your teacher's instructions.

Prepare the antibiotic and bacterium identification cards according to your teacher's instructions.

Prepare the mouth, nose, and wound identification signs according to your teacher's instructions.

Roles Three students get to be the nose, the mouth, and the wound. They stand across the width of the playing area, dividing it in half. Everyone else—bacteria and antibiotics—waits in lines at the mouth, nose, and wound to enter the body.

How to Play The game is divided into seven rounds.

Round One: The first round begins when the teacher gives out one set of cards: the nose gets two bacterium cards; the wound gets two bacterium cards; and the mouth gets one bacterium card and two antibiotic cards. When the teacher blows a whistle, the round starts. The mouth, nose, and wound hand their cards to the first students in their lines, allowing them to enter the body.

Inside the body, you and your classmates chase and tag each other. When you tag another student, both students unfold your cards and reveal your roles to each other. When students with the same cards tag each other, they fold their cards and continue playing the round. When a bacterium and an antibiotic tag each other, the antibiotic wins. The defeated bacterium student is out of the round, gives his or her bacterium card to the teacher, and gets in line to enter the body again in a subsequent round. The antibiotic student plays out the rest of the round.

The teacher signals the end of a round after 15 seconds. At the end of the round, students remaining in the body put their cards (bacterium or antibiotic) on the chair in the body and get back in line to enter the body again. The procedure for the other rounds is the same.

Deciding the Winner: The game ends when seven rounds have been completed. At the end of the seventh round, count the number of bacterium and antibiotic cards on the chair. The group with the most cards wins the game.

Recording your data

At the end of round seven:
Number of antibiotic cards ____.
Number of bacterium cards ____.

What did you find out?

What happened to the bacteria in "Bacterial Invaders"?

How was round four different from the other rounds?

What do the results of the game tell you about the use of antibiotics?

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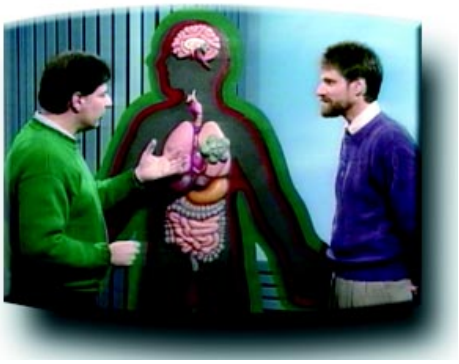
Cells in Chaos



What is cancer? How is a cancer cell different from a normal cell? What causes cancer? Can it be prevented? What is DNA and where can you find it in a cell?

Themes and Concepts

- the human cell
- personal health and disease
- reproduction and heredity

National Science Education Content Standards

Content Standard A: Students should develop abilities necessary to do scientific inquiry.
Content Standard C: Students should develop an understanding of structure and function in living systems.
Content Standard F: Students should develop an understanding of personal health.

Activities

1. *Building Blocks of Life—Approx. 20 min. prep; 60 min. class time*
Students examine normal human cells under a microscope to acquire a basic understanding of these building blocks of life. Students also compare normal cells with cancerous cells.

2. *A Look at DNA—Approx. 20 min. prep; 95 min. class time*
Students isolate DNA strands from onion cells and learn about the role of DNA in cancer. Bundles of precipitated DNA will be visible with the naked eye, and by viewing the precipitated DNA under a microscope, students will observe the threadlike structure of the DNA.

3. *Cells Gone Wild—Approx. 15 min. prep; 60 min. class time*
Students model the division of cancer cells and learn how their multiplication can be many times faster than normal cells.

More Information

Internet

Newton's Apple
http://www.ktca.org/newtons
(The official *Newton's Apple* web site with information about the show and a searchable database of science ideas and activities.)

National Cancer Institute
http://www.nci.nih/gov
(Offers a research database and links to other research sites about cancer.)

American Cancer Society
www.cancer.org
(Offers an excellent cancer information search function.)

Mayo Clinic Cancer Resource Center
http://www.mayohealth.org/mayo/common/htm/canhpage.htm
(A wealth of information, including an interactive health risk quiz.)

University of Pennsylvania Cancer Center
http://www.oncolink.com/
(Offers links and information about cancer.)

Internet Search Words

cancer
DNA
carcinogens
oncogenes

Cancer

Books and Articles

Cooper, Geoffrey M. The Cancer Book. London: Jones & Bartlett Publishers, 1993. (Excellent background information on cancer.)

VanCleave, Janice. The Human Body for Every Kid. New York: John Wiley and Sons, 1995. (Additional activities on cells, the lungs, and smoking.)

Community Resources

Local chapters of the American Cancer Society provide speakers and have many educational materials available.

National Cancer Institute

Medical doctors and clinics that specialize in cancer treatment

Local college and university pre-med programs and biology departments

Background

"Cancer"—perhaps the most devastating word a doctor can say to a patient—is one of the most deadly and difficult diseases to treat despite modern medicine. Cancer is a cellular disease, which is one reason it is so difficult to fight. The human body has more than a hundred different types of cells, all of which can form cancers unique to themselves.

The cell is the basic building block of living things, and cells almost all share the same characteristics. All cells have a cell membrane that functions as a protective wall, controlling what goes into and out of the cell. Inside almost all cells is a nucleus, the control center that contains deoxyribonucleic acid, a genetic material known as DNA. This DNA contains the blueprint, or formula, for a particular organism. The nucleus regulates cell processes, cell growth, and cell reproduction. When a cell divides, the DNA is replicated and two new cells, called daughter cells, are formed. Each of these daughter cells contain an exact copy of the DNA in the parent cell. Small changes in the DNA can lead to drastic changes in the cell, and it is with these tiny genetic changes or mutations that cancer has its roots.

When mutations cause groups of cells to divide too frequently, the cells form masses within the body called tumors. There are two types of tumors, benign and malignant. Benign tumors are common and, while they may interfere with bodily functions, they are rarely life-threatening. They do not travel to other parts of the body, and they can often be removed surgically.

Malignant, or cancerous tumors, are much more dangerous. They not only invade and destroy normal tissue but can send cancerous cells to other parts of the body through the blood or lymph systems. This process, which spreads cancer and makes it difficult to treat, is called metastasis.

The development of cancer is a complex interaction of our lifestyles, our genetic makeup, and our environment. It is theorized that some cancers have a strong genetic component that may make some people more likely to be stricken by those cancers. About 50 of the more than 100 known types of cancers may run in families, giving support to the idea that they may be genetically based.

Although some people may be genetically predisposed to getting some types of cancer, there is a lot you can do to avoid cancer. By eating a healthy diet, staying active, and avoiding carcinogens such as tobacco, you can substantially lessen the odds that you will ever hear your doctor say the dreaded "C" word.

Video & Stills

Video Segments

Introduction

26:34 to 27:04—Dave Huddleston poses some questions about cancer. (30 sec.)

Video Clip 1

27:05 to 28:22—Dr. Bruce Dan and David Heil discuss the cell and cancer. (1 min. 17 sec.)

Video Clip 2

28:22 to 29:12—Dr. Dan talks about the location and function of DNA and the differences between normal and cancerous cells. (50 sec.)

Video Clip 3

29:09 to 30:06—Dr. Bruce Dan demonstrates, with a photocopy machine, what happens when a cell multiplies too quickly. (57 sec.)

Video Clip 4

30:09 to 32:28—Dr. Dan discusses tumors and how cancer moves through the body. (2 min. 19 sec.)

Additional Resources

Button A

Photomicrograph of normal lung cells

Button B

Photomicrograph of cancerous lung cells

Button C

Photomicrograph of normal stomach cells

Button D

Computer model of DNA

Unit Assessment Answer Key

The Unit Assessment on the following page covers the basic concepts presented in the *Newton's Apple* video segment and the Background section of this guide. The assessment does not require completing all of the activities. The Unit Assessment may be used as a pre- or post-test. However, students should view the complete *Newton's Apple* video before doing this assessment. There is additional assessment at the end of each activity.

Think about it.

1. Cancer cells generally multiply much faster than normal cells.
2. A malignant tumor consists of cancerous cells; a benign tumor does not. Cells from benign tumors do not travel to other parts of the body, where cells from a cancerous tumor can.
3. More than 99% of DNA is found in the nucleus of a cell. DNA acts as the blueprint of life for the cell and the organism. It plays an important role in cell division.
4. No. Cancerous blood cells do not form tumors.
5. Maintain a good diet; eat a lot of fiber including fruits and vegetables; avoid tobacco products.

What would you say?

6. b 7. c 8. a 9. c 10. c

NEWTON'S APPLE Multimedia

Unit Assessment

What do you know about Cancer?

Write your answers in your journal or on a separate sheet of paper.

What do you think?

1. How are cancer cells different from normal cells?
2. What are the main differences between malignant and benign tumors?
3. What is the role of DNA in the cell and where is it found?
4. Do all types of cancer form tumors? Explain.
5. What are two things you can do to decrease your risk of getting cancer?

What would you say?

6. Which statement correctly describes cancer cells?
   a. Cancer cells do not have a nucleus.
   b. Cancer cells reproduce more quickly than normal cells.
   c. Cancer cells are larger than normal cells.
   d. Cancer cells reproduce more slowly than normal cells.

7. Which of the following is true?
   a. Cancer is contagious and you could catch it from someone.
   b. Cancer is caused by an alteration in the cell wall.
   c. Cancer is caused by a mutation in the cell.
   d. Cancer is always fatal.

8. All of the following may increase a person's risk for developing cancer except—
   a. vegetables.
   b. cigarettes.
   c. chewing tobacco.
   d. over exposure to the sun.

9. All of the following may reduce a person's risk of getting cancer except—
   a. yellow and orange fruits and vegetables.
   b. a high fiber diet.
   c. caffeine.
   d. sun screen.

10. When DNA in a cell is altered, it may cause the following—
    a. The cell produces two more cells almost identical to itself.
    b. The cell continues to divide at its normal rate.
    c. The cell may become cancerous.
    d. The cell keeps its normal shape.

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Activity 1

Building Blocks of Life

What does a normal human cell look like? How is a cancer cell different? How many kinds of cancer are there?

Getting Ready

Overview

Students begin their exploration of cancer by using cheek cells to learn about normal human cells. They draw the cells and label them. Then they compare normal cells to cancer cells by using prepared slides or the video stills.

Objectives

After completing this activity, students will be able to—

- identify, draw, and label the basic parts of a cell
- discuss types of human cells and how and why they differ in appearance
- describe the differences in the appearance of normal and cancerous cells

Time Needed

Preparation: approximately 20 minutes
Classroom: approximately 60 minutes

Materials

For each student:

- flat-edge toothpicks
- microscope slides
- cover slips

For each group of students:

- iodine
- pipettes or eyedroppers
- microscopes
- detergent for slide clean-up
- prepared slides of normal and cancer cells
- eye protection
- microprojector (optional)

Important Terms

cell — The basic structural unit of living organisms.

cell membrane — The thin outer cover-covering of an animal cell. The cell membrane maintains the shape of a cell and controls what enters and leaves the cell.

DNA — The abbreviation for deoxyribo-nucleic acid. DNA is a building-block molecule that contains information that controls how an organism functions and grows.

morphology — The structure and form of a cell.

nucleus — The cell's control center. The nucleus is the site where a cell's reproduction and growth functions occur.

Cancer

Here's How

Video Clip 1
27:05 to 28:22
Dr. Bruce Dan and David Heil discuss the cell and cancer. (1 min. 17 sec.)

Preparation

- Set up the computer to play the CD-ROM (or set up the VCR and cue the tape).
- Gather the materials.
- Make a copy of Activity Sheet 1 for each student.
- Review the information in the Background on page 24.

Engage (Approx. 15 minutes)

Find out what your students know about cancer. Ask for a show of hands from students who know someone—a friend or a relative—who has or had cancer. The number of students who have a friend or relative with cancer may be an indication of the frequency of the disease.

Ask students if they think cancer is curable. Is cancer catching? Is there only one kind of cancer that affects all parts of the body, or are there different types of cancer? Ask students if they have any idea how many kinds of cancer there are. Are some types more serious than others? What is the most common type? Accept all answers.

Show Video Clip 1 [27:05 to 28:22] in which Dr. Bruce Dan and David Heil discuss the cell and cancer. Then ask students if they can tell you what kind of disease cancer is. (It is a cellular disease.) What does it affect? (It affects cells, the building blocks of an organism.) Ask students what a cell is. Have they ever seen a human cell?

View the still of normal lung cells [Resource Button A on the CD-ROM]. Ask students to point out the nucleus and cell membrane. Ask students to explain the purpose of the cell membrane. (The cell membrane controls what goes into and out of the cell; it also helps keep the shape of the cell.) Ask students to explain the role of the nucleus. (The nucleus is the control center of the cell; it is in charge of cell regulation, growth, and reproduction.) Show the still of the cancerous lung cells [Resource Button B on the CD-ROM] and have students identify the cell membrane and nucleus of a cancer cell. Have students explain the difference between a normal cell and a cancer cell. Ask them how they might go about obtaining and looking at a human cell.

Guide on the Side

- You may wish to begin the lesson by viewing the Introduction from the Video Menu on the CD-ROM [26:34 to 27:04]. Find out what students already know about cancer. As a class, discuss the questions posed by Dave Huddleston.
- Remind students to follow established safety and hygiene procedures when doing this activity.
- You may wish to review the proper procedure for placing a coverslip on a microscope slide prior to students attempting it.
- If you have access to a microprojector, use it to show students a cheek cell and demonstrate how to draw and label the cell under high and low power views of a microscope.
- Students may need to dab the side of the coverslip with paper towel to remove excess iodine.
- Students may see particles of food along with their cheek cells if they are taking samples immediately after lunch. It might be helpful to have students rinse their mouth with water before taking the cheek cell sample.
- Advise students not to confuse air bubbles on the slide with cheek cells. The former appear as silver circles and do not stain.
- If time allows, you may wish to view the *Newton's Apple* video segment on cancer after completing the activity.

Activity 1

Explore (Approx. 45 minutes)

Tell students they are going to view their own cheek cells under a microscope and then draw and label the cell structures they can identify.

Demonstrate how to make a cheek cell slide. Wash your hands first. Scrape the inside of your cheek with the flat end of a toothpick. Show students how to place the scraping and saliva on the center of a microscope slide and carefully put one drop of iodine on top of it. (Warn students that iodine stains clothing.) Next, carefully put a coverslip on the slide. Wash your hands again following this procedure

Explain that cheek cells are transparent, and the iodine stains the cells to allow some structures to become visible. If there is a tiny bit of saliva on the slide, the iodine will adhere to the cheek cells better.

Under low power of a microscope, have students draw cells in the field of vision. Under high power, have them isolate one cell and draw and label the nucleus and cell membrane. You may wish to draw an example on the board so that students understand what is expected of them.

If time permits, have students draw normal stomach cells [Resource Button C on the CD-ROM]. Or students may view, draw, and label other cells using prepared slides.

Review the differences between normal and cancerous cells.

Evaluate

1. Show your students pictures of kinds of cells they have not seen and ask them to identify the cell structures.

2. Considering normal and cancerous lung cells, why would a cancerous lung cell be harmful to an organism? (They crowd out the normal cells. Cancer cells also reproduce faster than normal cells, gradually creating a tumor and taking over the organ.)

3. If a mechanic's wrench somehow changed shape, would it work the same? Relate this to a normal cancer cell. (No. Structure is related to function, and a wrench would not work efficiently if its shape were changed. Likewise, each type of cell has a specific function, and if the shape of a cell is changed, it performs less efficiently.)

Try This

Compare human cells with plant cells. Examine onion cells under a microscope and then draw them and compare them with the cells from your cheeks.

Research the discovery of the cell. Find out when scientists first identified the cell and its structures. Report your findings to the class.

Research nerve cells and muscle cells. Report on how their structure is related to their function.

Building Blocks of Life

Activity Sheet 1

Name _____ Class Period _____

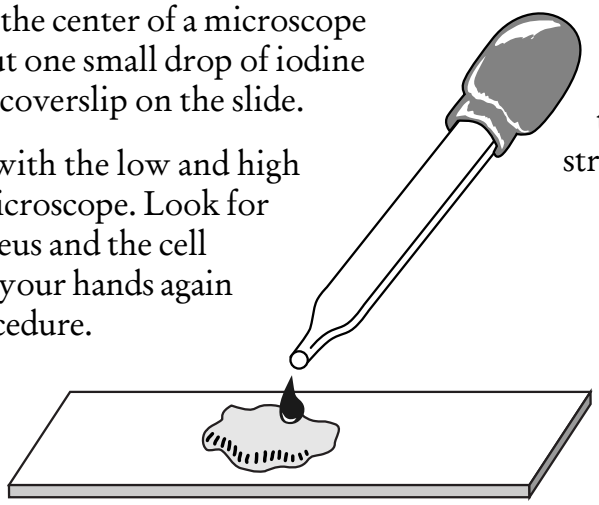
What you're going to do

You're going to take cheek cells from your mouth and observe them under a microscope.

How to do it

1. Wash your hands with soap and warm water. Scrape the inside of your cheek once with the flat end of a toothpick. Place the saliva and cells on the center of a microscope slide. Carefully put one small drop of iodine on top of it. Put a coverslip on the slide.

2. View the cells with the low and high powers of your microscope. Look for and draw the nucleus and the cell membrane. Wash your hands again following the procedure.



Recording your data

In your journal, draw the cheek cells you observed under the low-power view of your microscope. Next, draw one of your cheek cells as you observed it under the high power. Label the nucleus, the cell membrane, and any other structures you can observe.

What did you find out?

What is the general shape of your cheek cell?

What is the purpose of adding iodine to your cells?

What is the function of the cell membrane and nucleus?

Cheek cells are called epithelial cells. Epithelial cells form the covering or lining of body surfaces. Not all epithelial cells look alike. Why?

Share your observations with your classmates. Did they observe the same features you did? What might explain any difference?

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Activity 2

A Look at DNA

What is DNA? What is the role of DNA in a cell? Can you see DNA? What does it look like? How does DNA relate to cancer? Why do scientists sometimes remove DNA from cells?

Getting Ready

Overview

Students learn about the role of DNA in cancer and isolate DNA strands from onion cells. The procedure students use in this activity is similar to the way scientists isolated DNA when they first began investigating it. Bundles of precipitated DNA will be visible with the naked eye, and by viewing the bundles under a microscope, students will see the threadlike structure of the DNA.

Objectives

After completing this activity, students will be able to—

- describe strands of DNA from cells
- explain how DNA may be isolated and released from onion cells
- discuss the role of DNA in cancer

Time Needed

Preparation: approximately 20 minutes
Classroom: approximately 95 minutes

Materials

For the teacher:

- blender
- 2 medium onions, peeled and chopped
- 1/2 cup of warm water
- 1 tsp. salt

For each team of students:

- 1/8 cup of clear liquid soap of any kind (less concentrated soap works best)
- 5 wood toothpicks
- small coffee filter
- 8 oz. plastic cup
- small glass beaker or jar—about 100 ml (approximately 4 oz.)
- 1/8 tsp of meat tenderizer
- isopropyl alcohol at room temperature
- microscope slide and cover slip
- eyedropper
- microscope

Important Terms

molecule — Two or more atoms of the same or different elements that are joined together. A molecule is the smallest possible part of a substance that still has all the properties of the substance.

mutation — Changes in DNA that may affect the structure, functioning, and reproduction of a cell.

nuclear membrane — The thin wall that surrounds the nucleus of a cell and controls the movement of materials into and out of the nucleus.

Cancer

Video Clip 2
28:22 to 29:12
Dr. Bruce Dan talks about the location and function of DNA and the differences between normal and cancerous cells. (50 sec.)

Guide on the Side

- You may wish to begin the lesson by viewing the Introduction from the Video Menu on the CD-ROM [26:34 to 27:04]. Find out what students already know about cancer. As a class, discuss the questions posed by Dave Huddleston.
- It may take some practice getting the onion mixture the right consistency; the amount of water you need may vary. The mixture should flow slowly through the filter paper. If the mixture is too watery, the DNA will not come out of the solution when the alcohol is added.
- Tell students to pour the mixture through the coffee filter slowly so that it does not overflow. The liquid will pass through the filter slowly, so students need to be patient. However, students need only enough liquid to make a layer that fills the glass container one-third full. They do not have to wait for all of the liquid to pass through the filter.
- The amount of meat tenderizer that is needed is small. Have students wet the tip of the toothpick and dip it into the tenderizer. This will provide a sufficient quantity.
- The alcohol and cell solution form distinct layers when poured together. The alcohol is less dense than the cell solution and will float to the top. DNA is also less dense than the cell solution. As the DNA precipitates out of solution, it rises up to the alcohol layer.
- Viewed from the side of the jar, the DNA strands appear as a stringy substance swirling through the alcohol. DNA is clear and may appear white. Bubbles form on the DNA strands, making them easy to see.
- The strands that students see under the microscope are not individual molecules but millions of strands of DNA bunched together.
- If time allows, you may wish to view the *Newton's Apple* video segment on cancer after completing the activity.

Here's How

Preparation

- Set up the computer to play the CD-ROM (or set up the VCR and cue the tape).
- Prepare the onion mixture: Dissolve 1 tsp. of salt in 1/2 cup of warm water. Place the chopped onions in a blender. Add enough salt water to cover the onions. Turn on the blender at medium speed for several seconds. The mixture should still be a little lumpy with small pieces of onion floating in it.
- Gather all the materials, and practice the activity ahead of time.
- Make a copy of Activity Sheet 2 for each student.
- Review the information in the Background on page 24.

Engage (Approx. 15 minutes)

Ask students if they have ever heard of deoxyribonucleic acid. What about DNA? Ask them if they know where DNA is found in a cell. Ask if anyone has seen a model of DNA. What does it look like? Explain that DNA has a very complicated role: DNA contains the blueprint for life, and a change in the DNA may cause a cell to malfunction.

Show Video Clip 2 [28:22 to 29:12] in which Dr. Bruce Dan talks about the location and function of DNA in the cell and some differences between normal and cancerous cells. Ask students to explain the role of DNA in cancer. Ask students if they think plant cells also have DNA. How about insects? (All cells contain DNA.) Is it possible to see a DNA molecule without a microscope? Accept all answers. Show the computer model of DNA [Resource Button D]. Ask students what they observe about the model. Students should recognize the spiraling structure of the molecule.

In preparation for the activity, demonstrate the effect of an emulsifying agent—soap—on fat and fatty acids. Provide groups of students with a small cup of water into which several drops of cooking oil have been added. (Or use a petri dish on an overhead projector.) Have students add a drop of liquid soap into the oil and water and observe what happens. (The oil breaks up into smaller droplets.) Have students suggest reasons for what they observe. (Soap causes the molecules of oil to break apart.)

Explore (Approx. 80 minutes)

Tell students they are going to extract DNA from onion cells. Explain that single DNA strands are too small to be seen with the naked eye. DNA molecules are visible only with an electron microscope. Inform students that the activity will enable them to see clusters of DNA. Students should wear eye protection for the activity.

Activity 2

Explain that students will add several materials to an onion mixture in order to remove the DNA. Tell students you are providing them with a prepared mixture of chopped onions and salt water mixed in a blender. Have each student observe a drop of the mixture under a microscope and record what they observe. Separate students into teams for the activity.

Direct students to add a drop of liquid soap to the cell mixture. Have them stir the mixture slowly with a toothpick for five minutes, taking care that no bubbles are produced. Ask students what they think the purpose of the soap is. Ask them what cell structures they might have to break apart to remove the DNA. (Cell and nuclear membranes.) Tell students that these structures are composed of fat molecules that act to separate the materials inside the membrane from those that are outside the membrane.

Demonstrate how to place a coffee filter inside an empty plastic cup, and pour the cell mixture through the filter. Have students follow this procedure and collect the filtered solution in the cup. Next, have students fill a glass container about one-third full with the filtered solution. Tell them to add a tiny amount of meat tenderizer to the solution, using the flat end of a toothpick. Stir the solution with the toothpick for five minutes. Ask about the purpose of the meat tenderizer. (It helps break down the molecules further.)

Have students measure an amount of alcohol equal to the amount of the filtered onion solution. They should then slowly pour the alcohol into the glass container. The alcohol will form a layer at the top of the container. Have students observe the alcohol layer from the side of the container and record their observations. Tell students to gently stir the alcohol layer with a toothpick without disturbing the bottom layer. Have students record what they see on the toothpick. Have them view the material collected on the end of the toothpick under a microscope. Tell them to record what they observe.

Evaluate

1. DNA carries the code that determines all the characteristics of a cell and organism. All cells in a single organism carry the same DNA code. The DNA of different organisms carry different codes. Do you think the DNA in each strand you observed is identical? Explain. (If the material used in the solution came from a single onion, the DNA should be nearly the same in each strand. Some variation might exist due to mutations that naturally occur in cells. If the onion material came from more than one onion, the DNA will vary.)

2. Why is it important for scientists to know about the structure of different cellular parts in order to separate DNA from cells? (Different parts of the cell are made of different materials. Scientists can make up experimental procedures that destroy one part of the cell but leave other parts unaffected.)

Try This

Repeat the activity using other plant or animal cells, such as dried peas (soaked), liver, spinach, or baker's yeast. Compare the characteristics of the DNA you extract from different types of foods. All samples should produce long strands of DNA material. You may have to filter some materials through a sieve rather than filter paper.

There is a great range in the number of chromosomes in the DNA of different organisms. For example, humans have 3 billion base pairs, while corn has 4.5 billion and a salimander has 79 billion. Research the number of base pairs in different plants and animals. Present your findings to the class.

A Look at DNA

Activity Sheet 2

Name _____ Class Period _____

What you're going to do

You're going to isolate and observe DNA molecules from onion cells.

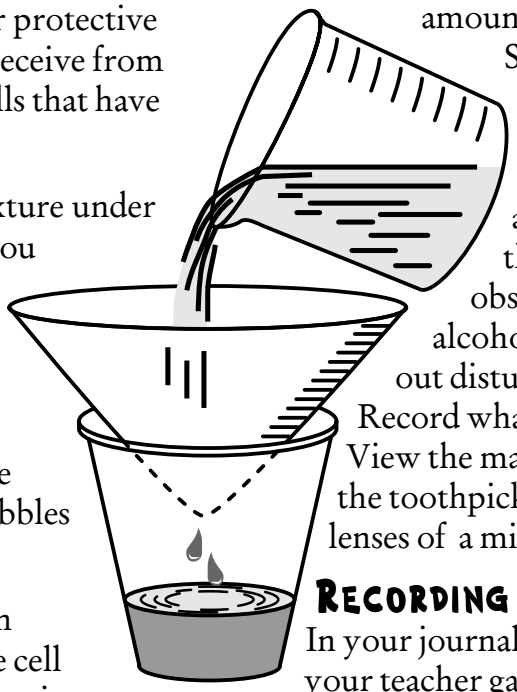
How to do it

1. Work in small groups. Wear protective goggles. The cell mixture you receive from your teacher contains onion cells that have been blended with saltwater.

2. View a drop of the cell mixture under the microscope. Record what you observe on a sheet of paper.

3. Add a drop of liquid soap to the cup containing the cell mixture. Stir the mixture very slowly with a toothpick for five minutes, taking care that no bubbles are produced.

4. Place a coffee filter inside an empty plastic cup, and pour the cell mixture through the filter, collecting the filtered solution in the cup. Next, fill a glass beaker about one-third full with the filtered solution. Using the flat end of a toothpick, add a tiny amount of meat tenderizer to the solution, and gently stir the solution with the toothpick for five minutes.



5. Measure an amount of alcohol equal to the amount of the filtered onion solution. Slowly pour the alcohol into the glass container. The alcohol will form a layer at the top of the container. Observe the alcohol layer from the side of the container and record your observations. Gently stir the alcohol layer with a toothpick without disturbing the bottom layer. Record what you see on the toothpick. View the material collected on the end of the toothpick with low and high power lenses of a microscope. Record what you see.

Recording your data

In your journal describe the onion mixture your teacher gave you. What does it look like under the microscope?

Record what you observe in the alcohol layer when you look at it from the side of the container. Observe it for several minutes and write down your observations.

Describe what you observed on the toothpick under the microscope. Draw what you observed under two views.

What did you find out?

Compare the onion cell and saltwater mixture that you observed under the microscope with the material you saw on the end of the toothpick.

What do the soap and meat tenderizer do?

Why do you think scientists want to separate individual cell parts from the rest of the cell?

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Activity 3

Cells Gone Wild

How quickly do cancer cells divide? Why do they divide faster than normal cells? How does the rapid reproduction of cancer cells affect an organ or tissue?

Getting Ready

Overview

Students use calculators to simulate cell division and learn about the consequence of the rapid division of cancer cells. Student review the differences between normal cells and cancer cells.

Objectives

After completing this activity, students should be able to—

- model the cell division of normal and cancerous cells
- discuss the effect of the rapid growth of cancer cells
- graph comparative rates of cell division

Time Needed

Preparation: approximately 15 minutes
Classroom: approximately 60 minutes

Materials

For the teacher:

- stopwatch (optional)

For each pair of students:

- two calculators
- graph paper

Important Terms

cell division — The process in which a cell produces two new and almost identical cells.

metastasis — The spread of cancer from one part of the body to another.

tumor — A group of cells that divides too quickly and forms in masses within organs.

Cancer

Here's How

Video Clip 3
29:09 to 30:06
Dr. Bruce Dan demonstrates, with a photocopy machine, what happens when a cell multiplies too quickly. (57 sec.)

Video Clip 4
30:09 to 32:28
Dr. Bruce Dan discusses tumors and how cancer moves through the body. (2 min. 19 sec.)

Guide on the Side

- You may wish to begin the lesson by viewing the Introduction from the Video Menu on the CD-ROM [26:34 to 27:04]. Find out what students already know about cancer. As a class, discuss the questions posed by Dave Huddleston.
- Graphing calculators may be used in this activity. However, students should develop their own graphs to compare the data on normal and cancerous cells.
- If students know how to use a computer spreadsheet program, they may wish to model what would happen after 20 or 100 cell divisions.
- You may want to review bar graphs and line graphs and how to set up the x- and y-axis. Explain that double bar graphs are used to show comparisons at certain points in time, while double line graphs compare two trends over a period of time.
- You may wish to plan a discussion on how cancer cells travel through the body during the early part of this activity, when students are waiting for cells to divide.
- If time allows, you may wish to view the *Newton's Apple* video segment on cancer after completing the activity.

Preparation
- Set up the computer to play the CD-ROM (or set up the VCR and cue the tape).
- Gather the materials for the student activity.
- Make a copy of Activity Sheet 3 for each student.
- Review the information in the Background on page 24.

Engage (Approx. 15 minutes)

Ask students what would happen if one species of animal suddenly multiplied faster than it had in the past. What would happen to the balance of nature, for example, if suddenly there were three times the number of deer as there were the previous summer? What would happen to the food supply? What would deer do to the bark and buds of trees? Would the wolf population increase?

Explain that a similar phenomenon can take place in our bodies. Suddenly cells that have mutated may multiply very rapidly. Tell students that cancer cells do not all divide at the same rate, but they all multiply faster than normal cells. Explain that the cancerous cells of Burkitt's lymphoma can double in 24 hours. Generally, cancers of the blood and lymph reproduce quickly and, as a result, they are more responsive to treatment with chemicals that attack dividing cells. View the Video Clip 3 [29:09 to 30:06] in which Dr. Bruce Dan demonstrates, with a photocopying machine, what happens when a cell multiplies too quickly.

Ask students about the consequence of the rapid multiplication of cancer cells. What is the effect of rapid cell division on various organs of our bodies? Show the Video Clip 4 [30:09 to 32:28] in which Dr. Dan discusses tumors. Ask students what might happen when a cell suddenly begins to divide more quickly than normal. Have students refer to the stills of malignant leukemia cells. Ask students how cancerous blood cells are different from normal blood cells.

Explore (Approx. 45 minutes)

Tell students that they are going to model the multiplication or division of both normal and cancer cells in an organ.

Have students work in pairs. One student will model the division of normal cells, and the other will model the multiplication of cancerous cells. Each student should have a calculator and graph paper.

Activity 3

Explain that the normal cells will reproduce every two minutes. The cancer cells will divide in an irregular pattern. Tell students that when you say, "Cell division." that everyone—normal cells and cancer cells—will multiply the total on their calculator by 2. Explain that the cancer cells will reproduce at a different rate than normal cells. Tell students who are modeling the cancer cells that in addition to the regular cell division, they will multiply their totals by 2 every time you say, "Cancer."

Students should each set up a data table in their science journals like the one described in Activity Sheet 3. Students should record the total on their calculator at the two-minute intervals when all cells divide. The students modeling cancer cell division will have different totals than the students modeling normal cell division.

Begin by having all students enter 2 on their calculators. After about a minute, say, "Cancer." Then after two minutes say, "Cell division." Tell students to record their totals in their data tables. Check to see that students are following the procedure correctly. (At this point the normal cell total is four and the cancer cell total is eight.) Continue the procedure until normal cells have divided ten times. Have the cancer cells divide at increasingly shorter intervals, gradually reducing the interval to 10-15 seconds for the final period.

After the last cell division, have pairs of students graph their results. Discuss their graphs and ask students for their reactions to the rate of division for cancer cells.

Evaluate

1. A person has been treated in the past for stomach cancer and the cancer has been in remission for several years. Now, however, the person is dying of a brain tumor caused by cancer. What type of brain cancer does the person probably have? How did the person most likely contract brain cancer? (Cancer cells from the stomach probably traveled to the brain and formed a tumor there. The brain tumor actually consists of stomach cancer cells.)

2. Explain that cancer progresses in individuals at different rates. How could the activity be altered to reflect this. (Students representing the cancer cells could multiply their totals by 2 at different timed intervals.)

3. A surgeon removes a malignant tumor from a patient's leg. Does this necessarily make the patient cancer-free? What could happen to this patient? (There may still be cancer cells in the body of the patient. The cells could produce a new tumor on the patient's leg, or the cells could be carried to another part of the body and a tumor could be produced there.)

Try This

Design your own simulation and include cell division times for normal versus cancer cells. Your model should also include metastasis of the original cancer.

Investigate current cancer treatments and discuss the types of cancer targeted and the remission rates for these cancers. Are there some cancers that respond well to particular treatments? Why? Are there some cancers that show a poor response rate? Why?

Invite a local doctor or cancer specialist to come to class and discuss symptoms that people should watch for to detect cancer early. Have the speaker stress the importance of a healthy lifestyle in the prevention of certain kinds of cancer.

Cells Gone Wild

Activity Sheet 3

Name_____ Class Period _____

What you're going to do

You're going to simulate the rate at which normal and cancerous cells divide and multiply.

How to do it

1. Work with a partner. Each of you should have a calculator and graph paper. One of you will model the cell division of a normal cell. The other partner will model the cell division of a cancer cell.

2. Set up a data table in your journal similar to the one described below. You should have ten cell divisions.

3. Listen to your teacher for a signal to simulate cell division. Begin by keying a "2" on your calculator. If you are representing normal cells, multiply the total by 2 only when your teacher says, "Cell division." If you represent cancer cells, multiply the total by 2 when your teacher says, "Cell division," and also when the teacher says, "Cancer." Record the total number of cells you have after each "normal" division.

Recording your data

Set up a data table in your journal. Indicate if you are doing normal cells or cancer cells and record the following information.

Total number of cells after "Cell Division."

1st division _____

2nd division _____

3rd division _____

4th division _____

5th division _____

6th division _____

7th division _____

8th division _____

9th division _____

10th division _____

Use your data and your partner's data to make a line or bar graph comparing the growth of normal and cancer cells.

What did you find out?

Was there a large difference in the number of normal and cancer cells after two regular cell divisions? What about at the end? Describe the difference.

Explain why cancerous tumors can grow so rapidly.

What were the most surprising or interesting results of this activity?

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